The high cost of diarrheal illness for urban slum households: a cost recovery approach

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Title Page

Title: The High Cost of Diarrheal Illness for Urban Slum Households: A Cost Recovery Approach: A Cohort Study

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Article Summary:
1) Article Focus:
- *To determine how costly diarrheal illness is for poor urban slum households.*
- *To test the hypothesis that the cumulative cost that an urban slum community incurs due to diarrhea would, in a relatively short period, cover the cost of water and sanitation infrastructure.*

2) Key Messages:
- *Urban poor slum households spend a significant amount of money and proportion of their income on costs related to diarrhea.*
- *The cumulative costs that diarrhea causes for poor urban slum households is significant and can, over a short period of time, surpass the cost of water and sanitation infrastructure.*
- *Innovative financing schemes and investments should be made for urban slum water and sanitation infrastructure development to prevent illness and its role in driving poverty.*

3) Strengths and Limitations:
- *A major strength of this study was its use of systematic longitudinal weekly household level data of income and expenses for the entire slum community as it relates to a common illness.*
- *A major limitation was the diversity of the community and thus the resulting variability in cost estimates and wide standard deviations.*
- *A further limitation was the imprecision of cost estimates from recall rather than an exact budget or financial diary.*

ABSTRACT

Objectives: Rapid urbanization has often meant that public infrastructure has not kept pace with growth leading to urban slums with poor access to water and sanitation and high rates of diarrhea with greater household costs due to illness. This study sought to determine the monetary cost of diarrhea to urban slum households in Kaula Bandar slum in Mumbai, India. The study also tested the hypotheses that the cost of water and sanitation infrastructure may be surpassed by the cumulative costs of diarrhea for households in an urban slum community.

Design: A cohort study using a baseline survey of a random sample followed by a systematic longitudinal household survey. The baseline survey was administered to a random sample of households. The systematic longitudinal survey was administered to every available household in the community with a case of diarrhea for a period of five weeks.

Participants: Every household in Kaula Bandar was approached for the longitudinal survey and all available and consenting adults were included.

Results: The direct cost of medical care for having at least one person in the household with diarrhea was 205 rupees. Other direct costs brought total expenses to 291 rupees. Adding an average loss of 55 rupees per household from lost wages and monetizing lost productivity from homemakers gave a total loss of 409 rupees per household. During the 5-week study period this community lost an estimated 163,600 rupees or $3,635 US dollars due to diarrheal illness.

Conclusions: The lack of basic water and sanitation infrastructure is expensive for urban slum households in this community. Financing approaches that transfer that cost

to infrastructure development to prevent illness would be feasible. These findings along with the myriad of unmeasured benefits of preventing diarrheal illness add to pressing arguments for investment in basic water and sanitation infrastructure.

Introduction

Globally, urban slums are characterized by dense populations with poor access to sanitation and clean water due to non-existent or poorly developed basic infrastructure [1-4]. In Mumbai, India 62% of the city's population lives in such slums but they are concentrated on approximately 9% of the city's land [5]. While the proportion of the urban slum population in Mumbai without access to basic water and sanitation is difficult to measure given the lack of clear definitions and differences between registered and unregistered slums, it is reasonably understood that most lack access to these basic services.

Urban slum dwellers in general have difficulty accessing sufficient quantities of quality water for many reasons, including lack of infrastructure, poor reliability, as well as cost. In Mumbai slums, research has shown that even in registered slums, where the government has provided some water access, the supply is intermittent, lasting at most four hours a day, for example, between 6 and 10 am in the morning [6,7].

Kaula Bandar (KB), the study site, is an unregistered urban slum with a population of approximately 10,000 to 12,000 people all wedged onto a single wharf. Kaula Bandar is located on land that officially belongs to the Mumbai Port Trust, bringing it technically under the authority of the federal government. Given this peculiar legal status, although it resides in the city of Mumbai, this slum has very limited access to civic services normally provided by the city government, the Municipal Corporation of Greater Mumbai (MCGM). Consequently, nearly all children and 14% of adult residents defecate in the surrounding ocean, while 59% of adults use a pay toilet and 40% use public toilets that are barely functional [8]. Residents of this community also report that there are many days at a time, especially during the summer season, when there is no water flow through their haphazard water network. This network is a mixture of water bought through private sellers and illegal connections into the city water supply. The intermittent water access not only leads to diminished supply shared among too many users, but also to increased water contamination [9].

The system of water distribution in Kaula Bandar is haphazard and much more unreliable than the formal distribution system provided by the city government. Middle class residents of Mumbai have city water that is piped directly into their homes, and many registered slum residents receive water through city-provided common community water taps. In contrast, Kaula Bandar, an unregistered slum, has no formal water supply. A few years ago, some residents of Kaula Bandar discovered an old underground fire department pipe, and started accessing it with a series of connections linked to pumps. These KB residents now sell and distribute the water to local residents through an elaborate system of hoses. This complex system is problematic, as its extensive web requires many interval pumps to maintain water flow and because the exposed, poorly maintained hosing traverses a precarious route through seawater that includes refuse and feces.

Residents of KB report that there are days at a time when water is not available through this complex hose network system, leaving the 12,000 residents without a reliable source of water. This happens quite frequently during the summertime due to water pressure issues, or loss of the motors that are taken away by the authorities every 5-6 months and must be repurchased by the water sellers. In these dire circumstances, residents obtain water from neighboring communities up to 5 kilometers away; buy water sold from expensive private water tanker trucks; or simply go without water.

This water delivery system is not only inferior because of quality and quantity but it is also very costly. For water piped into their homes, middle class Mumbai residents are charged merely 3.5 rupees per 1000 liters of water. In contrast, KB residents pay anywhere from 146 to 464 rupees per 1000 liters of water [9]. The ultimate cost to KB residents is significant because they are indirectly charged for not only for the distributors' salaries, but the pump fuel costs, water hose replacement costs, pump replacement costs and large bribes to the local police to avoid seizures of the pump motors.

Clean water, proper sanitation infrastructure and hygiene practices comprise the three biggest factors in ensuring freedom from water-born illness. The disparity in access felt by urban slums translates into human lives lost, particularly in children under the age of five, who are especially vulnerable to the effects of waterborne illness, including diarrhea leading to increased morbidity and mortality [10-29]. Annual cases of Diarrhea among urban slum dwellers in Mumbai is estimated to be as high as 614/1000 people, with 30-60 per cent of households and 12-30 per cent individuals affected by water-related diseases a year [6]. In Kaula Bandar, 91.2% of KB residents stated the lack of water affected the health of their family members [8].

Poor access to sufficient quantities and quality of water along with inadequate waste management leads to waterborne illness [10-29]. This burden of disease carries real monetary costs in the form of lost days of employment, health care costs, cost of increased water and toilet use. The total costs of inadequate water access includes the lifelong cost of malnutrition and stunting in the form of impaired school performance and delayed entry into the labor market resulting in lesser earnings [32-34]. The World Health Organization estimates that globally, the lack of adequate water and sanitation leads to health costs of at least US$340 million for households and US$7 billion for national health systems [30]. The World Bank estimates that India specifically loses 6.4% of its GDP every year to water and sanitation related diseases [35]. Locally, a large community survey of Kaula Bandar showed that 39.3% of individuals felt that the community's lack of water negatively affected their ability to go to work, 9.2% to go to school, 4% to study, 1.4% to start a new business, 1.5% to increase productivity in current business [8]. However, there are no data translating this into the actual monetary costs of the diarrheal illness in Kaula Bandar.

A study of 959 households in KB showed that a large proportion of Kaula Bandar occupants (45.7%) had monthly direct health expenditures (doctors, medicines, hospital fees) greater than 500 rupees, which for families living on meager income falls under the category of catastrophic expenditure [8, 31].

Given high household expenditure on illness, preventative health interventions would be cost-effective. This study investigates the cost of diarrheal illness in the community to determine the household monetary cost of having a member with diarrhea. These costs are calculated as direct and monetized indirect costs to determine the amount that diarrheal illness contributes to household expenditure and lost productivity. These costs are then projected for the community at large as figures to compare against the cost of potential interventions to improve water and sanitation infrastructure.

Methods

Sampling and Data Collection

For data collection, two surveys were administered. The surveys were designed through community focus group discussions, the authors' experience with the community from previous work as well as extensive pretesting various versions of the survey and individual questions from January to May 2011. Official data collection for the study occurred in July 2011, during the monsoon season. This study was undertaken in collaboration with the local research organization, Partners for Urban Knowledge Action and Research (PUKAR).

Community based "barefoot researchers" trained in social science research at PUKAR who had previous experience administering surveys in the community verbally administered the surveys in the local language for this study. The study only had one exclusion and one inclusion criteria. Households with a head of household less than 18 years of age were excluded due to IRB approval for adults only and respondents that could reasonably answer questions about household finances were included. Most often the respondent was a woman. The term household in this study refers to all members living in a dwelling.

Baseline survey

The baseline survey included questions about water access, hygiene, and sanitation and average household expenditure on various goods in the Kaula Bandar community. These households did not necessarily have a diarrheal case. The entire community of Kaula Bandar was mapped and each household coded with an individual designation developing a comprehensive registry of households. A random number generator was then used to collect data on a sample of households from this registry resulting in 203 households in the baseline survey

Longitudinal survey:

The longitudinal survey was designed to understand the direct and indirect costs associated with diarrheal cases in Kaula Bandar. Direct costs included all health-care associated costs including ORS, medications, transport to reach a provider and provider fees as well as increased costs due to the extra water purchased, extra kerosene purchased for boiling and extra money spent on accessing a toilet facility. Indirect costs included wages lost by earners with diarrhea or those caring for persons with diarrhea and households chores not completed.

During the month of July 2011, the community barefoot researchers visited all 2922 households in Kaula Bandar weekly for a total of five weeks. If a head of household over 18 years of age was available, and the household had a case of diarrhea for which the disease course had been completed during the past week, they were invited to participate in the study. Survey data were only collected for households with a completed case of diarrhea so that the data would reflect full costs for the entire episode of illness. Active, ongoing cases were recorded every week so that researchers could specifically follow-up with those households the next week (once the diarrheal illness was completed) with the full survey questionnaire. Four hundred households with a case of diarrhea contributed to the weekly survey data during the five week study period in the month of July 2011.

Data analysis:
The data was recorded by hand on paper and transferred to an EpiData database by the data manager as soon as results were provided to PUKAR. Statistical analysis was performed using STATA MP ver. 10, College Station, TX. Data on cost measures from the longitudinal survey were analyzed after eliminating the top 5% and bottom 5% of values among the population to exclude the effect of outliers.

Data storage
Only researchers associated with the PUKAR team had access to the survey information. All data regarding specific homes from which data was collected was stored at the PUKAR office on a password protected hard disk. All results of the study were analyzed and are published in an anonymized fashion.

Ethical Considerations
Heads of households provided informed consent. The households who participated in the study as well as other residents received education on recognizing signs and symptoms of diarrhea through pictorial posters. The female members of the household who usually bore the brunt of caretaking for persons with diarrhea in the home were taught about initial treatments such as ORS and were educated on when their family members should been seen by a doctor in case of deterioration in condition. This study received Institutional Review Board (IRB) approval from PUKAR Institutional Ethics Committee as well as the Partners Human Research Committee associated with Harvard Medical School based researchers in Boston, MA USA.

Results:

A total of 203 households, 6.9% of the 2922 households in the community, provided data for the baseline survey. Systematically visiting every household for the weekly survey resulted in 400 households providing data as these were the homes with completed diarrhea cases during the study period. The sample of 400 households represents 13.7% of Kaula Bandar homes. The percentage of homes occupied and thus available for survey every given week ranged from 67% to 73.2%, showing that at least 2/3 of the community was available for survey each week. Of these available households, there was a negligible non-response rate ranging from 0.5% to 1.2%, thus, having minimal effect on the study results.

Baseline demographic information from the baseline survey, displayed in Table 1, shows that the population of this slum is predominantly male and young with 1.2 males for every female with a median age of 20. Part of this ratio is related to the presence of many single migrant laborers in the community. Additionally, only about 10% of the population was over the age of 40. Children under five years of age, representing the most vulnerable population to diarrheal illness, make up slightly over 15% of the population.

General household financial data from the baseline survey, displayed in Table 2, shows basic income and consumption information. While household income ranged in a normal distribution, the median income in this community from both the baseline and weekly surveys falls between 5000 to 6000 rupees per month. Each household had on average 1.7 wage earners per household with 32% of the population earning a wage. About 26.6% of the households are able to save some money each month and of those that save, the median savings in 1500 rupees.

After discussions with households and advice from persons within the community, household costs were broken down into several major categories: rent, food, water, electricity and kerosene. While these categories do not comprehensively capture the total costs of each household, they represent the major recurring basic costs that each household incurs for their general welfare. The average monthly expenditure on these basics excluding water was 4,609 rupees with an additional median of 300-450 rupees spent on water alone.

Diarrhea in this community was reported on a weekly basis during the 5-week course of the study as active cases and cases that had just completed that week. The general weekly prevalence of diarrhea per household ranged from 5.9% to 9.2% during this monsoon season. This is likely a higher prevalence for this community as compared to the general year given the season, which induces more flooding and, thus, greater contact with fecal coliforms as well as increased water source contamination.

The costs of diarrhea to these households was measured and reported here in terms of direct and indirect costs, Tables 3. Basic direct costs included all health-care associated costs including ORS, medications, transport to a provider and provider fees. Other direct costs were tabulated separately as increased costs due to the extra water purchased, extra kerosene purchased for boiling and extra money spent on accessing a toilet facility. Indirect costs represented the wages lost by earners with diarrhea or those caring for persons with diarrhea and household chores not completed. While some of the indirect costs have a specific monetary value, lost time and household chores are extrapolated.

The mean basic direct cost for each household with diarrhea was 205 rupees. The total other direct costs (water, kerosene, toilet) resulted in a mean of 86 rupees per household. In the community, 16.5% of households lost some wages due to diarrhea and while this value varied, these households lost a median of 500 rupees for the episode. Spreading this loss over all the households and calculating the loss overall yields a mean loss of 55 rupees per household.

Given that the majority of women in this community are not wage earners, we attempted to capture the productivity that homemakers provide to the household and the amount of that productivity that is lost by diarrheal illness. Using a replacement value methodology with a hypothetical maid and focusing on 9 major daily tasks conducted by women with a an urban replacement cost of $6.1 USD or 274 rupees per task per month during the time of this study, we calculated the total indirect costs to households from a women's lost productivity [37]. The 274 rupees per month per daily task converts into an average cost of 9 rupees per individual task. On average, women in the household with diarrhea were unable to complete an average of 7 tasks that week due to a case of diarrhea in the household translating into a loss of 63 rupees per household.

Given the values above, the cost of illness to each household from a case of diarrhea can be reported in several ways. The basic direct cost is 205 rupees. Other direct costs of 86 rupees gives a total of 291 rupees. Adding the mean loss of 55 rupees per household from lost wages brings the total to 346 rupees per household and adding the monetized lost productivity from homemakers of 63 rupees brings the total to 409 rupees.

Simply using the 400 cases of diarrhea from this community found during this 5-week study period from the houses available for survey alone yields a total basic direct cost of 82,000 rupees or $1,822 USD using the exchange rate present at time of study.

The complete total cost of 409 rupees per household yields a loss of 163,600 rupees or $3,635 USD to the community over the five-week study period.

These results rely on household incidence of diarrhea regardless of age and no reliable measure of diarrheal incidence at the household unit exists for a similar population to estimate the yearly costs for this population. Using a conservative assumption, however, that each household will suffer at least one case of diarrhea per year, the basic direct cost of diarrheal illness in this community of 2922 households yields a yearly total community-wide cost of 1,195,098 rupees ($26,557 USD).

Table 1: Baseline Demographic Information

Male	55%
Female	45%
Age (median)	20 years
Children under 5	15%

Table 2: General Household Financial Information (All amounts reported in rupees [Rs])

Income (median)	Rs 5000-5999
Basic monthly expenses (Rent, food, electricity, kerosene)	Rs 4609
Water expenses (median)	Rs 300-449
Possess ration card	68.5%
Save money each month	26.6%

Table 3: Mean Household Costs per Diarrheal Illness in Rupees (Rs) ± Standard Deviation (SD)

Metric	Cost ± SD	n
Basic direct costs (ORS, provider fee, transport, medication costs)	205 ± 190	310
Other direct costs (extra water, kerosene and toilet fees)	86 ± 81	201
Lost wages	55 ± 160	384
Homemaker's productivity loss – monetized	63	400
Total	409	

Discussion:

This study provides direct household level data on the cost of diarrheal illness to urban slum residents in this community. Longitudinally interviewing every available household consecutively for five straight weeks provides rigorous insight into the weekly income and expenditure habits of these residents as they relate to diarrheal illness.

Given the thorough nature of the data collection, this study provides strong evidence that diarrheal illness incurs significant direct and indirect costs to urban slum households. More importantly, this study shows how over a very short period of time, infrastructure upgrades for water and sanitation systems that transfer these costs from the back end of paying for illness to the front end could pay for themselves. With every illness episode costing each household loses an average of 248 rupees in direct costs and 515 rupees in total costs. Reducing and eliminating these illness episodes can provide a significant savings benefit that can be used to finance the infrastructure upgrades.

This study adds further evidence against the myth that urban slum populations do not have the financial capacity to pay for improved infrastructure. Just as many reports have shown that these households in fact pay a high price for basic goods and services from both official and unofficial sources, this study shows that households also pay a high price for illness. While not a novel concept, this study provides concrete numbers on the cost that illness inflicts on the urban poor and shows how these households, as a community, have the financial capacity to finance infrastructure they need simply from the savings in prevented illness. Although this is not an argument for such a model, it adds further evidence that upfront investment in basic infrastructure is cost-effective. The savings realized by these households from an infrastructure investment could then be put towards other basic needs in nutrition, education and health.

Despite the rigorous methodology, the study suffers from a few limitations. While the values for cost are rigorously collected from every available household, they are the best estimate from the surveyed adult. The data were not gathered from detailed budgets, financial diaries or accounts held by these households but rather by recall. The diversity of the population within this community added to the variability and high standard deviations seen in the data. This reflects the true nature of many urban slums that have a high variability in socio-economic status. Another limitation is that while improved water and sanitation infrastructure can have a significant impact on reducing illness, proper hygiene plays another major role. Infrastructure upgrades alone will not eliminate the burden of diarrheal illness and thus, all of the cost from diarrheal illness cannot be attributed to the lack of such infrastructure. Accordingly, the total savings realized by such an infrastructure upgrade would be less. This community, however, has a high reported rate of hand hygiene with 86% of households washing their hands before eating and 90% washing their hands after defecating. Additionally, 87% of the population reported using soap either before eating, after defecating or both. Thus, most of the costs estimated from this study are all likely costs that can be saved through infrastructure upgrades to compliment this hand hygiene. While estimates on the exact magnitude of benefit from water and sanitation infrastructure vary, a recent review concluded that piped water to each household alone could give up to 63% reduction in diarrheal prevalence [38]. Adding a sanitation intervention would further reduce this prevalence and allow more complete cost recovery. Unlike hand hygiene compliance, only 56.5% persons with diarrhea in this study used ORS and a higher rate of ORS use might have averted more costly healthcare expenses contributing to the overall cost estimates in this study. This limitation is hypothetical, however, in that it is unclear if any of the cases that did not use ORS would have needed it or even sought care elsewhere to increase the household costs. Finally, the care-seeking behavior for diarrhea itself may be viewed as a limitation as most cases do not require care outside the home and better education might prevent these costs from being incurred by families. Whatever the impact of improved care-seeking behavior on the cost estimates, however, this study estimates the current real cost households incur due to diarrheal illness which can be saved and put towards public health interventions aimed at reducing this burden, including infrastructure upgrades.

Many of the estimates of cost here may actually be underestimates. As this community did not have many female wage earners in the household, another community with more female wage earners (common among urban households) would presumably have had a higher indirect cost of lost wages. Additionally, the time spent on activities such as travelling to the toilet and fetching water were not adequately collected in this study, adding further indirect costs to diarrheal illness not included in this estimate. We could not collect enough data on savings and debt among these households to make a correlation between illness and debt in this community but previous studies have shown that illness is an indebting event for many urban poor. A larger and more comprehensive study may have been able to capture that value showing a further cost in the lost savings and higher payments made on loans for such borrowing. Finally, the weight of evidence that diarrheal illness incurs even greater indirect costs than those measured here is staggering [38]. When malnutrition, stunting, poor school performance, delayed and incomplete education and poor cognitive development are included along with the resulting decreased economic opportunities as well as mortality on overall GDP, there is an even greater cost attributable to diarrheal illness in urban slum communities similar to Kaula Bandar.

Given the study findings, policy-makers and those with programs aimed at aiding urban slum populations should understand the potential savings from preventing diarrheal illness with improved water and sanitation infrastructure. A current intervention to provide piped water to Kaula Bandar has an estimated cost of 2.5 million rupees. While this intervention will not provide each household with an individual tap, community taps that increase water availability have the potential to reduce diarrhea by 25% from such an intervention. Using even this modest estimate of reduction, one can easily see how the community can finance this intervention over a relatively short period of time from the diarrheal cost savings alone.

This financial argument for water and sanitation infrastructure complements the right to water and sanitation that all persons have. This right to water and sanitation is part of a larger legal and human rights framework. On July 28th, 2010 the UN General Assembly adopted resolution 64/292 acknowledging that clean water and sanitation are essential to achieving all human rights [41]. International organizations and all states and are directed to provide adequate and affordable access to clean water and sanitation for all persons. This research on the community and household financial implications of poor water and sanitation adds to this human rights approach with a further pragmatic and operational validation of the need for clean water and sanitation provision to even the most difficult to reach populations.

This study shows that programs and policies that allow communities to finance and fund such interventions are possible. Whether government financed through taxes or privately through fees or micro lending or even socially through savings cooperatives, financial vehicles to promote infrastructures upgrades can be financially viable methods of development. While this study argues for improved infrastructure, the cost savings from improved health and illness prevention can be used to finance various types of health promotion and public health activities. Further research is needed on the best methods of preventing illness, improving care-seeking behavior and healthcare quality among urban slum communities. This study shows that such interventions in urban slum communities can be financed through improving the consequent health benefits.

Contributorship statement:

All authors met guidelines for authorship with substantive input on study design, pilot testing instruments, fata collection and analysis and final manuscript writing and editing. The major design of the study was developed by the first, second and last authors (RBP, HS, AP). Survey instrument development, pilot testing, editing and data collection was done by all and heavily by (SS, TS, KS, MN and RS). Data analysis was performed primarily by RBP with assistance from (HS, MN and RS). Manuscript writing was done primarily by (RBP and HS) with editing from all of the the other authors.

Data sharing:

There is additional unpublished data on general income and expenses as well as care seeking behavior for the households that can be made available upon request and discussion with the corresponding author.

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

The high cost of diarrheal illness for urban slum households: a cost recovery approach

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Title Page

Title: The High Cost of Diarrheal Illness for Urban Slum Households: A Cost Recovery Approach: A Cohort Study

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Article Summary:
1) Article Focus:
- *To determine how costly diarrheal illness is for poor urban slum households.*
- *To test the hypothesis that the cumulative cost that an urban slum community incurs due to diarrhea could, over a period of time, help cover the cost of water and sanitation infrastructure.*

2) Key Messages:
- *Urban poor slum households spend a significant amount of money and proportion of their income on costs related to diarrhea.*
- *The cumulative costs that diarrhea causes for poor urban slum households is significant and can, over a period of time, help finance the cost of water and sanitation infrastructure.*
- *Innovative financing schemes and investments should be made for urban slum water and sanitation infrastructure development to prevent illness and its role in driving poverty.*

3) Strengths and Limitations:
- *A major strength of this study was its use of systematic longitudinal weekly household level data of income and expenses for the entire slum community as it relates to a common illness.*
- *A major limitation was the diversity of the community and thus the resulting variability in cost estimates and wide standard deviations.*
- *A further limitation was the imprecision of cost estimates from recall rather than an exact budget or financial diary.*

ABSTRACT

Objectives: Rapid urbanization has often meant that public infrastructure has not kept pace with growth leading to urban slums with poor access to water and sanitation and high rates of diarrhea with greater household costs due to illness. This study sought to determine the monetary cost of diarrhea to urban slum households in Kaula Bandar slum in Mumbai, India. The study also tested the hypotheses that the cost of water and sanitation infrastructure may be surpassed by the cumulative costs of diarrhea for households in an urban slum community.

Design: A cohort study using a baseline survey of a random sample followed by a systematic longitudinal household survey. The baseline survey was administered to a random sample of households. The systematic longitudinal survey was administered to every available household in the community with a case of diarrhea for a period of five weeks.

Participants: Every household in Kaula Bandar was approached for the longitudinal survey and all available and consenting adults were included.

Results: The direct cost of medical care for having at least one person in the household with diarrhea was 205 rupees. Other direct costs brought total expenses to 291 rupees. Adding an average loss of 55 rupees per household from lost wages and monetizing lost productivity from homemakers gave a total loss of 409 rupees per household. During the 5-week study period this community lost an estimated 163,600 rupees or $3,635 US dollars due to diarrheal illness.

Conclusions: The lack of basic water and sanitation infrastructure is expensive for urban slum households in this community. Financing approaches that transfer that cost

to infrastructure development to prevent illness may be feasible. These findings along with the myriad of unmeasured benefits of preventing diarrheal illness add to pressing arguments for investment in basic water and sanitation infrastructure.

Introduction

Globally, urban slums are characterized by dense populations with poor access to sanitation and clean water due to non-existent or poorly developed basic infrastructure.[1-4] In Mumbai, India 62% of the city's population lives in such slums but they are concentrated on approximately 9% of the city's land.[5] While the proportion of the urban slum population in Mumbai without access to basic water and sanitation is difficult to measure given the lack of clear definitions and differences between registered and unregistered slums, it is reasonably understood that most lack access to these basic services.

Urban slum dwellers in general have difficulty accessing sufficient quantities of quality water for many reasons, including lack of infrastructure, poor reliability, as well as cost. In Mumbai slums, research has shown that even in registered slums, where the government has provided some water access, the supply is intermittent, lasting at most four hours a day, for example, between 6 and 10 am in the morning.[6,7]

Kaula Bandar (KB), the study site, is an unregistered urban slum with a population of approximately 10,000 to 12,000 people all wedged onto a single wharf. Kaula Bandar is located on land that officially belongs to the Mumbai Port Trust, bringing it technically under the authority of the federal government. Given this peculiar legal status, although it resides in the city of Mumbai, this slum has very limited access to civic services normally provided by the city government, the Municipal Corporation of Greater Mumbai (MCGM). Consequently, nearly all children and 14% of adult residents defecate in the surrounding ocean, while 59% of adults use a pay toilet and 40% use public toilets that are barely functional.[8] Residents of this community also report that there are many days at a time, especially during the summer season, when there is no water flow through their haphazard water network due to water pressure issues, or loss of the motors that are taken away by the authorities every 5-6 months and must be repurchased by the water sellers. This network is a mixture of water bought through private sellers and illegal connections into the city water supply. The intermittent water access not only leads to diminished supply shared among too many users, but also to increased water contamination.[9]

The system of water distribution in Kaula Bandar is complex and much more unreliable than the formal distribution system provided by the city government. Middle class residents of Mumbai have city water that is piped directly into their homes, and many registered slum residents receive water through city-provided common community water taps. In contrast, Kaula Bandar, an unregistered slum, has no formal water supply. A few years ago, some residents of Kaula Bandar discovered an old underground fire department pipe, and started accessing it with a series of connections linked to pumps. These KB residents now sell and distribute the water to local residents through an elaborate system of hoses. This complex system is problematic, as its extensive web requires many interval pumps to maintain water flow and because the exposed, poorly maintained hosing traverses a precarious route through seawater that includes refuse and feces.

Residents of KB report that there are days at a time when water is not available through this complex hose network system, leaving the community residents without a reliable source of water. This happens quite frequently during the summertime. In these dire circumstances, residents obtain water from neighboring communities up to 5 kilometers away; buy water sold from expensive private water tanker trucks; or simply go without water.

This water delivery system is not only inferior because of quality and quantity but it is also very costly. For water piped into their homes, middle class Mumbai residents are charged merely 3.5 rupees per 1000 liters of water. In contrast, KB residents pay anywhere from 146 to 464 rupees per 1000 liters of water.[9] The ultimate cost to KB residents is significant because they are indirectly charged for not only for the distributors' salaries, but the pump fuel costs, water hose replacement costs, pump replacement costs and large bribes to the local police to avoid seizures of the pump motors.

Clean water, proper sanitation infrastructure and hygiene practices comprise the three biggest factors in ensuring freedom from water-born illness. The disparity in access felt by urban slums translates into human lives lost, particularly in children under the age of five, who are especially vulnerable to the effects of waterborne illness, including diarrhea leading to increased morbidity and mortality.[10-16] Annual cases of diarrhea among urban slum dwellers in Mumbai is estimated to be as high as 614/1000 people, with 30-60 per cent of households and 12-30 per cent individuals affected by water-related diseases a year.[6] In Kaula Bandar, 91.2% of KB residents stated the lack of water affected the health of their family members.[8]

Poor access to sufficient quantities and quality of water along with inadequate waste management leads to waterborne illness.[10,17] This burden of disease can carry real monetary costs in the form of lost days of employment, health care costs, cost of increased water and toilet use. The total costs of inadequate water access may be even greater. As decreased access to safe drinking water and adequate sanitation contribute to waterborne illness, malnutrition and in turn, stunting, this results in poorer cognitive development and performance in school.[18-20] These setbacks may result in delayed entry into the labor market and lesser earnings. Although not based on empirical data, the World Health Organization estimates that globally, the lack of adequate water and sanitation leads to health costs of at least US$340 million for households and US$7 billion for national health systems.[21] The World Bank estimates that India specifically loses 6.4% of its GDP every year to water and sanitation related diseases.[22]

Locally, a large community survey of Kaula Bandar showed that 39.3% of individuals felt that the community's lack of water negatively affected their ability to go to work, 9.2% to go to school, 4% to study, 1.4% to start a new business, 1.5% to increase productivity in current business.[8] However, it is unknown if these effects are directly tied to the negative health implication of lacking water or other problems associated with poor access. Also, there are no data translating this into the actual monetary costs of the diarrheal illness in Kaula Bandar.

A study of 959 households in KB showed that a large proportion of Kaula Bandar occupants (45.7%) had monthly direct health expenditures (doctors, medicines, hospital fees) greater than 500 rupees, which for families living on meager income falls under the category of catastrophic expenditure.[8, 23]

Given high household expenditure on illness, preventative health interventions, implemented correctly, may not only be cost-effective but more affordable for many urban poor. This study investigates the cost of diarrheal illness in the community to determine the household monetary cost of having a member with diarrhea. These costs are calculated as direct and monetized indirect costs to determine the amount that diarrheal illness contributes to household expenditure and lost productivity. These costs are then projected for the community at large as figures to compare against the cost of potential interventions to improve water and sanitation infrastructure. While the presence of this infrastructure would not eliminate all cases of diarrhea or all modes of transmission, it would significantly reduce many common sources and the availability of clean water would allow for better hygiene to protect against some sources that are not eliminated.

Methods

Sampling and Data Collection

For data collection, two surveys were administered. The surveys were designed through community focus group discussions, the authors' experience with the community from previous work as well as extensive pretesting various versions of the survey and individual questions from January to May 2011. Official data collection for the study occurred in July 2011, during the monsoon season. This study was undertaken in collaboration with the local research organization, Partners for Urban Knowledge Action and Research (PUKAR).

Community based "barefoot researchers" trained in social science research at PUKAR who had previous experience administering surveys in the community verbally administered the surveys in the local language for this study. Using data-collectors from the community has many advantages and became essential to study of this type. It most importantly allowed the research team to gain social capital with the community and improve participation. It also allowed fine-tuning of survey questions given the insights that they provide about their own water, sanitation and health practices. These community based researchers assisted with pilot testing many questions to ensure that the questions captured the information they were intended to capture. Multiple rounds of training avoided initial disadvantages such as inconsistent survey administration with re-phrasing questions, not probing certain responses, recording assumptions instead of responses and leading questions. Additionally, a member of the study team accompanied each "barefoot researcher" in the field.

The study only had one exclusion and one inclusion criteria. Households with a head of household less than 18 years of age were excluded due to IRB approval for adults only and respondents that could reasonably answer questions about household finances were included. Most often the respondent was a woman. The term household in this study refers to all members living in a dwelling.

Baseline survey

The baseline survey included questions about water access, hygiene, and sanitation and average household expenditure on various goods in the Kaula Bandar community. These households did not necessarily have a diarrheal case. The entire community of Kaula Bandar was mapped and each household coded with an individual designation developing a comprehensive registry of households. A random number generator was then used to collect data on a sample of households from this registry resulting in 203 households in the baseline survey. This baseline survey was meant to simply get an understanding of general household income and expenditure as well as health practices to better formulate the longitudinal survey. Some questions were repeated after reformulation in the longitudinal survey based on the baseline survey results.

Longitudinal survey:

The longitudinal survey was designed to understand the direct and indirect costs associated with diarrheal cases in Kaula Bandar. Diarrhea was defined according to the World health Organization definition and study staff as well as survey respondents were taught this definition when collecting data. Direct costs included all health-care associated costs including ORS, medications, transport to reach a provider and provider fees as well. Avoidance costs included expenses from the extra water purchased, extra kerosene purchased for boiling and extra money spent on accessing a toilet facility. Indirect costs included wages lost by earners with diarrhea or those caring for persons with diarrhea and households chores not completed.

During the month of July 2011, the community barefoot researchers visited all 2922 households in Kaula Bandar weekly for a total of five weeks. This period of five weeks was used in order to collect a reasonable sample of households representing almost 10% of the calendar year and stay within the constraints of the resources available. If a head of household over 18 years of age was available, and the household had a case of diarrhea for which the disease course had been completed during the past week, they were invited to participate in the study. Survey data were only collected for households with a completed case of diarrhea so that the data would reflect full costs for the entire episode of illness. Active, ongoing cases were recorded every week so that researchers could specifically follow-up with those households the next week (once the diarrheal illness was completed) with the full survey questionnaire. Four hundred households with a case of diarrhea contributed to the weekly survey data during the five week study period in the month of July 2011.

Given that the majority of women in this community are not wage earners, we attempted to capture the productivity that homemakers provide to the household and the amount of that productivity that is lost by diarrheal illness as an opportunity cost. Using a replacement value methodology with a hypothetical maid and focusing on 9 major daily tasks conducted by women with a an urban replacement cost of $6.1 USD or 274 rupees per task per month during the time of this study, we calculated the total indirect costs to households from a women's lost productivity.[24] The 274 rupees per month per daily task convert into an average cost of 9 rupees per individual task. To ensure that only chores that were foregone are included, women were asked to report if these chores were actually not done or they were completed with free help from another another person or simply delayed in the day or week. The opportunity cost was then the product of the forgone number chores and the cost to hire a person to complete that chore using the hypothetical maid and urban replacement cost above.

Data analysis:

The data was recorded by hand on paper and transferred to an EpiData database by the data manager as soon as results were provided to PUKAR. Statistical analysis was performed using STATA MP ver. 10, College Station, TX. Data on cost measures from the longitudinal survey were analyzed after eliminating the top 5% and bottom 5% of values among the population to exclude the effect of outliers. Although some catastrophic events may have been excluded by this process, we found that the mean and median values did not differ greatly but some variability at the two ends was eliminated by eliminating the outliers.

Data storage

Only researchers associated with the PUKAR team had access to the survey information. All data regarding specific homes from which data was collected was stored at the PUKAR office on a password protected hard disk. All results of the study were analyzed and are published in an anonymized fashion.

Ethical Considerations

Heads of households provided informed consent. The households who participated in the study as well as other residents received education on recognizing signs and symptoms of diarrhea through pictorial posters. The female members of the household who usually bore the brunt of caretaking for persons with diarrhea in the home were taught about initial treatments such as ORS and were educated on when their family members should been seen by a doctor in case of deterioration in condition. This study received Institutional Review Board (IRB) approval from PUKAR Institutional Ethics Committee as well as the Partners Human Research Committee associated with Harvard Medical School based researchers in Boston, MA USA.

Results:

A total of 203 households, 6.9% of the 2922 households in the community, provided data for the baseline survey. Systematically visiting every household for the weekly longitudinal survey resulted in 400 households providing data as these were the homes with completed diarrhea cases during the study period. There was some repetition with 49 homes reporting cases twice within the study period and 9 households reporting three weeks with a case of diarrhea. The sample of 400 household events represents 13.7% of Kaula Bandar homes. The age distribution of cases showed that all children under five years of age accounted for 35% of cases while those under one-year accounted for 11%. Those aged 5-18 years accounted for another 25% of cases and adults made up the reaming 40%.

The percentage of homes occupied and thus available for survey every given week ranged from 67% to 73.2%, showing that at least 2/3 of the community was available for survey each week. Of these available households, there was a negligible non-response rate ranging from 0.5% to 1.2%, thus, having minimal effect on the study results.

Baseline demographic information from the baseline survey, displayed in Table 1, shows that the population of this slum is predominantly male and young with 1.2 males for every female. Part of this ratio is related to the presence of many single migrant laborers in the community. Additionally, only about 10% of the population was over the age of 40. Children under five years of age, representing the most vulnerable population to diarrheal illness, make up slightly over 15% of the population.

General household financial data from the baseline survey, displayed in Table 1, shows basic income and consumption information. Each household had on average 1.7 wage earners per household with 32% of the population earning a wage. Of the roughly quarter of households that are able to save each month, the median savings in 1500 rupees.

After discussions with households and advice from persons within the community, household costs were broken down into several major categories: rent, food, water, electricity and kerosene. While these categories do not comprehensively capture the total costs of each household, they represent the major recurring basic costs that each household incurs for their general welfare. The average monthly expenditure on these basics excluding water was 4,609 rupees with an additional median of 300-450 rupees spent on water alone.

Diarrhea in this community was reported on a weekly basis during the 5-week course of the study as active cases and cases that had just completed that week. The general weekly prevalence of diarrhea per household ranged from 5.9% to 9.2% during this monsoon season.

The costs of diarrhea to these households was measured and reported here in terms of direct medical costs, avoidance costs and lost wages from income and costs from homemakers' productivity loss, Table 2.

Basic direct costs included all health-care associated costs including ORS, medications, transport to a provider and provider fees. Although transport to a provider is commonly considered a non-medical cost, we combine it here because access to healthcare is a major issue for the urban poor and transport to a healthcare provider is an important part of the cost to access healthcare. The majority of people, 62%, accessed a private provider with a local doctor and 15% went to a pharmacy for care.

Avoidance costs were tabulated separately as increased costs due to the extra water purchased, extra kerosene purchased for boiling and extra money spent on accessing a toilet facility.

Lost wages represented the wages lost by income-earners with diarrhea or those caring for persons with diarrhea. In the community, 16.5% of households lost some wages from income-earning employment due to diarrhea. While this value varied, these households lost a median of 500 rupees of income for the episode from missed employment. Spreading this loss over all the households and calculating the loss overall yields a mean loss of 55 rupees per household.

On average, women in the household with a case of diarrhea were unable to complete an average of 7 tasks that week due to a case of diarrhea in the household. The cost from the monetized value of foregone chores based on the replacement cost method of hiring a maid is reported.

Given the values above, the cost of illness to each household from a case of diarrhea can be reported in several ways. The basic direct cost is 205 rupees. Avoidance costs of 86 rupees gives a total of 291 rupees. Adding the mean loss of 55 rupees per household from lost income brings the total to 346 rupees per household and adding the monetized productivity lost from homemakers of 63 rupees brings the total to 409 rupees.

Simply using the 400 cases of diarrhea from this community found during this 5-week study period from the houses available for survey alone yields a total basic direct cost of 82,000 rupees or $1,822 USD using the exchange rate present at time of study. The complete total cost of 409 rupees per household yields a loss of 163,600 rupees or $3,635 USD to the community over the five-week study period.

These results rely on household incidence of diarrhea regardless of age and no reliable measure of diarrheal incidence at the household unit exists for a similar population to estimate the yearly costs for this population. Using a conservative assumption, however, that each household will suffer at least one case of diarrhea per year, the basic direct cost of diarrheal illness in this community of 2922 households yields a yearly total community-wide cost of 1,195,098 rupees ($26,557 USD).

Table 1: General Household Information from Baseline Survey

Male	55%
Female	45%
Age (median)	20 years
Children under 5	15%
Income (median)	Rs 5000-5999
Basic monthly expenses (Rent, food, electricity, kerosene)	Rs 4609
Water expenses (median)	Rs 300-449
Possess ration card	68.5%
Save money each month	26.6%

Table 2: Mean Household Costs per Diarrheal Illness in Rupees (Rs) ± Standard Deviation (SD)

Metric	Cost ± SD	n
Basic direct costs *(ORS, provider fee, transport, medication costs)*	205 ± 190	310
Avoidance costs (*extra water, kerosene and toilet fees)*	86 ± 81	201
Lost wages from income	55 ± 160	384
Homemaker's productivity loss *(foregone chores monetized)*	63	400
Total	409	

Discussion:

This study provides direct household level data on the cost of diarrheal illness to urban slum residents in this community. Longitudinally interviewing every available household consecutively for five straight weeks provides rigorous insight into the weekly income and expenditure habits of these residents as they relate to diarrheal illness. Given the thorough nature of the data collection, this study provides strong evidence that diarrheal illness incurs significant costs to urban slum households. More importantly, this study provides expenditure and illness costs that can be compared against the cost of infrastructure upgrades for water and sanitation systems. The savings from lower costs of water and sanitation from improved infrastructure can be put towards paying for that infrastructure and over time completely finance it. This study provides evidence that the savings from a reduction in some cases of diarrhea from such infrastructure may also help finance it by these costs from the back end of paying for illness to the front end could pay for themselves. With every illness episode each household loses an average of 205 rupees in direct basic costs and 346 rupees in total avoidable total costs. Reducing these illness episodes can provide a significant savings benefit that can be used to finance the infrastructure upgrades.

This study adds further evidence to break the myth that urban slum populations do not have the financial capacity to pay for improved infrastructure. Just as many reports have shown that these households in fact pay a high price for basic goods and services from both official and unofficial sources, this study shows that households also pay a high price for illness given that it represents 7-8 percent of their monthly income and almost 30% of their weekly income. While not a novel concept, this study provides concrete numbers on the cost that illness inflicts on the urban poor and shows how these households, as a community, have the financial capacity to finance infrastructure they need simply from the savings in prevented illness. Although this is not an argument for such a model, it adds further evidence that upfront investment in basic infrastructure can be financially supported by a resulting reduction in illness. The savings realized by these households from an infrastructure investment could then be put towards other basic needs in nutrition, education and health.

Despite the rigorous methodology, the study suffers from a few limitations. While the values for cost are rigorously collected from every available household, they are the best estimate from the surveyed adult. The data were not gathered from detailed budgets, financial diaries or accounts held by these households but rather by recall. The diversity of the population within this community added to the variability and high standard deviations seen in the data. This reflects the true nature of many urban slums that have a high variability in socio-economic status. Another limitation is that while improved water and sanitation infrastructure can have a significant impact on reducing illness, proper hygiene plays another major role. Infrastructure upgrades alone will not eliminate the burden of diarrheal illness and thus, all of the cost from diarrheal illness cannot be attributed to the lack of such infrastructure. Accordingly, the total savings realized by such an infrastructure upgrade would be less. This community, however, has a high reported rate of hand hygiene with 86% of households washing their hands before eating and 90% washing their hands after defecating. Additionally, 87% of the population reported using soap either before eating, after defecating or both. Thus, most of the costs estimated from this study are all likely costs that can be saved through infrastructure upgrades to compliment this hand hygiene. While estimates on the exact magnitude of benefit from water and sanitation infrastructure vary, a recent meta-analysis of interventions in developing countries concluded that improved water supply could reduce diarrhea by about 25%.[25] A sanitation intervention would further provide reductions. This meta-analysis concluded that a combination of multiple interventions including improved water supply and quality, improved sanitation and hygiene could reduce diarrheal disease by 33%.[25] Given that hand hygiene was high in this community, the estimated reduction in diarrhea by a combined water and sanitation intervention would likely be slightly less.

Only 56.5% persons with diarrhea in this study used ORS. A higher rate of early ORS use might have averted more costly healthcare expenses such as the need to access a healthcare provider thereby reducing the overall cost of the illness measured in this study. This limitation is hypothetical, however, because it is unclear if any of the cases that did not use ORS would have needed it or if they were associated with seeking more expensive care elsewhere to increase the household costs. Finally, the care-seeking behavior for diarrhea itself may be viewed as a limitation as most cases do not require care outside the home and better education might prevent these costs from being incurred by families. Whatever the impact of improved care-seeking behavior on the cost estimates, however, this study estimates the current real cost households incur due to diarrheal illness which can be saved and put towards public health interventions aimed at reducing this burden, including infrastructure upgrades.

Many of the estimates of cost here may actually be underestimates. This particular community did not have many female income earners in the household. Many urban slum communities have a higher rate of women that are employed in the informal sector but still live in communities such as this one with poor water and sanitation infrastructure. If that informal employment were outside the home, they would forgo income from having to stay home with an ill child. Additionally, the time spent on activities such as travelling to the toilet and fetching water were not adequately collected in this study, adding further indirect costs to diarrheal illness not included in this estimate. We could not collect enough data on savings and debt among these households to make a correlation between illness and debt in this community but previous studies have shown that illness is an indebting event for many urban poor. A larger and more comprehensive study may have been able to capture that value showing a further cost in the lost savings and higher payments made on loans for such borrowing. Finally, if malnutrition, stunting, poor school performance, delayed and incomplete education and poor cognitive development could be included along with the resulting decreased economic opportunities as well as mortality on overall GDP, there would be an even greater cost attributable to diarrheal illness in urban slum communities similar to Kaula Bandar.

Given the study findings, policy-makers and those with programs aimed at aiding urban slum populations should understand the potential savings from preventing diarrheal illness with improved water and sanitation infrastructure. A current intervention to provide piped water to Kaula Bandar has an estimated cost of 2.5 million rupees. While this intervention will not provide each household with a personal tap, community taps that increase water availability and ensure quality have the potential to reduce diarrhea morbidity. The potential reduction in diarrhea from such an intervention may aid the community to help finance this intervention over a period of time from the lower diarrheal cost savings by adding to the savings from cheaper water.

This financial argument for water and sanitation infrastructure complements the right to water and sanitation that all persons have. This right to water and sanitation is part of a larger legal and human rights framework. On July 28th, 2010 the UN General Assembly adopted resolution 64/292 acknowledging that clean water and sanitation are essential to achieving all human rights.[26] International organizations and all states and are directed to provide adequate and affordable access to clean water and sanitation for all persons. This research on the community and household financial implications of poor water and sanitation adds to this human rights approach with a further pragmatic and operational validation of the need for clean water and sanitation provision to even the most difficult to reach populations.

This study provides data on the cost of diarrheal illness to urban slum households and allows an analysis of cost-recovery for various interventions. This study begins to explore how the expected health benefits may help finance such interventions in urban slum communities. Whether government financed through taxes or privately through fees or micro lending or even socially through savings cooperatives, financial vehicles to promote infrastructures upgrades may be financially viable methods of development. While this study argues for improved infrastructure, the potential cost savings from improved health and illness prevention may be used to finance various types of health promotion and public health activities. These potential savings should be calculated and considered in cost-benefit analyses. Further research is needed on the best methods of preventing illness, improving care-seeking behavior and healthcare quality among urban slum communities.

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Title Page

Title: The High Cost of Diarrheal Illness for Urban Slum Households: A Cost Recovery Approach: A Cohort Study

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Key Words:
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Word Count: ~~4174~~4817

Article Summary:
1) Article Focus:

- *To determine how costly diarrheal illness is for poor urban slum households.*
- *To test the hypothesis that the cumulative cost that an urban slum community incurs due to diarrhea ~~would, in~~could, over a ~~relatively short~~ period~~,~~ of time, help cover the cost of water and sanitation infrastructure.*

2) Key Messages:

- *Urban poor slum households spend a significant amount of money and proportion of their income on costs related to diarrhea.*
- *The cumulative costs that diarrhea causes for poor urban slum households is significant and can, over a ~~short~~ period of time, ~~surpass~~help finance the cost of water and sanitation infrastructure.*
- *Innovative financing schemes and investments should be made for urban slum water and sanitation infrastructure development to prevent illness and its role in driving poverty.*

3) Strengths and Limitations:

- *A major strength of this study was its use of systematic longitudinal weekly household level data of income and expenses for the entire slum community as it relates to a common illness.*
- *A major limitation was the diversity of the community and thus the resulting variability in cost estimates and wide standard deviations.*
- *A further limitation was the imprecision of cost estimates from recall rather than an exact budget or financial diary.*

ABSTRACT

Objectives: Rapid urbanization has often meant that public infrastructure has not kept pace with growth leading to urban slums with poor access to water and sanitation and high rates of diarrhea with greater household costs due to illness. This study sought to determine the monetary cost of diarrhea to urban slum households in Kaula Bandar slum in Mumbai, India. The study also tested the hypotheses that the cost of water and sanitation infrastructure may be surpassed by the cumulative costs of diarrhea for households in an urban slum community.

Design: A cohort study using a baseline survey of a random sample followed by a systematic longitudinal household survey. The baseline survey was administered to a random sample of households. The systematic longitudinal survey was administered to every available household in the community with a case of diarrhea for a period of five weeks.

Participants: Every household in Kaula Bandar was approached for the longitudinal survey and all available and consenting adults were included.

Results: The direct cost of medical care for having at least one person in the household with diarrhea was 205 rupees. Other direct costs brought total expenses to 291 rupees. Adding an average loss of 55 rupees per household from lost wages and monetizing lost productivity from homemakers gave a total loss of 409 rupees per household. During the 5-week study period this community lost an estimated 163,600 rupees or $3,635 US dollars due to diarrheal illness.

Conclusions: The lack of basic water and sanitation infrastructure is expensive for urban slum households in this community. Financing approaches that transfer that cost

to infrastructure development to prevent illness ~~would~~may be feasible. These findings along with the myriad of unmeasured benefits of preventing diarrheal illness add to pressing arguments for investment in basic water and sanitation infrastructure.

Introduction

Globally, urban slums are characterized by dense populations with poor access to sanitation and clean water due to non-existent or poorly developed basic infrastructure~~ [~~.[1-4~~].~~] In Mumbai, India 62% of the city's population lives in such slums but they are concentrated on approximately 9% of the city's land~~ [~~.[5~~].~~] While the proportion of the urban slum population in Mumbai without access to basic water and sanitation is difficult to measure given the lack of clear definitions and differences between registered and unregistered slums, it is reasonably understood that most lack access to these basic services.

Urban slum dwellers in general have difficulty accessing sufficient quantities of quality water for many reasons, including lack of infrastructure, poor reliability, as well as cost. In Mumbai slums, research has shown that even in registered slums, where the government has provided some water access, the supply is intermittent, lasting at most four hours a day, for example, between 6 and 10 am in the morning~~ [~~.[6,7~~].~~]

Kaula Bandar (KB), the study site, is an unregistered urban slum with a population of approximately 10,000 to 12,000 people all wedged onto a single wharf. Kaula Bandar is located on land that officially belongs to the Mumbai Port Trust, bringing it technically under the authority of the federal government. Given this peculiar legal status, although it resides in the city of Mumbai, this slum has very limited access to civic services normally provided by the city government, the Municipal Corporation of Greater Mumbai (MCGM). Consequently, nearly all children and 14% of adult residents defecate in the surrounding ocean, while 59% of adults use a pay toilet and 40% use public toilets that are barely functional~~ [~~.[8~~].~~] Residents of this community also report that there are many days at a time, especially during the summer season, when there is no water flow through their haphazard water network~~.~~ due to water pressure issues, or loss of the motors that are taken away by the authorities every 5-6 months and must be repurchased by the water sellers. This network is a mixture of water bought through private sellers and illegal connections into the city water supply. The intermittent water access not only leads to diminished supply shared among too many users, but also to increased water contamination~~ [~~.[9~~].~~]

The system of water distribution in Kaula Bandar is ~~haphazard~~complex and much more unreliable than the formal distribution system provided by the city government. Middle class residents of Mumbai have city water that is piped directly into their homes, and many registered slum residents receive water through city-provided common community water taps. In contrast, Kaula Bandar, an unregistered slum, has no formal water supply. A few years ago, some residents of Kaula Bandar discovered an old underground fire department pipe, and started accessing it with a series of connections linked to pumps. These KB residents now sell and distribute the water to local residents through an elaborate system of hoses. This complex system is problematic, as its extensive web requires many interval pumps to maintain water flow and because the exposed, poorly maintained hosing traverses a precarious route through seawater that includes refuse and feces.

Residents of KB report that there are days at a time when water is not available through this complex hose network system, leaving the ~~12,000~~community residents without a reliable source of water. This happens quite frequently during the summertime ~~due to water pressure issues, or loss of the motors that are taken away by the authorities every 5-6 months and must be repurchased by the water sellers~~. In these dire circumstances, residents obtain water from neighboring communities up to 5 kilometers away; buy water sold from expensive private water tanker trucks; or simply go without water.

This water delivery system is not only inferior because of quality and quantity but it is also very costly. For water piped into their homes, middle class Mumbai residents are charged merely 3.5 rupees per 1000 liters of water. In contrast, KB residents pay anywhere from 146 to 464 rupees per 1000 liters of water~~ [~~.[9~~].~~] The ultimate cost to KB residents is significant because they are indirectly charged for not only for the distributors' salaries, but the pump fuel costs, water hose replacement costs, pump replacement costs and large bribes to the local police to avoid seizures of the pump motors.

Clean water, proper sanitation infrastructure and hygiene practices comprise the three biggest factors in ensuring freedom from water-born illness. The disparity in access felt by urban slums translates into human lives lost, particularly in children under the age of five, who are especially vulnerable to the effects of waterborne illness, including diarrhea leading to increased morbidity and mortality~~ [~~.[10-~~29].~~16] Annual cases of ~~Diarrhea~~diarrhea among urban slum dwellers in Mumbai is estimated to be as high as 614/1000 people, with 30-60 per cent of households and 12-30 per cent individuals affected by water-related diseases a year~~ [~~.[6~~].~~] In Kaula Bandar, 91.2% of KB residents stated the lack of water affected the health of their family members~~ [~~.[8~~].~~]

Poor access to sufficient quantities and quality of water along with inadequate waste management leads to waterborne illness~~ [~~.[10~~-29].~~,17] This burden of disease ~~carries~~can carry real monetary costs in the form of lost days of employment, health care costs, cost of increased water and toilet use. The total costs of inadequate water access ~~includes the lifelong cost of~~may be even greater. As decreased access to safe drinking water and adequate sanitation contribute to waterborne illness, malnutrition and in turn, stunting~~ in the form of impaired school~~, this results in poorer cognitive development and performance ~~and~~in school.[18-20] These setbacks may result in delayed entry into the labor market ~~resulting in~~and lesser earnings~~ [32-34]. The~~. Although not based on empirical data, the World Health Organization estimates that globally, the lack of adequate water and sanitation leads to health costs of at least US$340 million for households and US$7 billion for national health systems~~ [30].~~.[21] The World Bank estimates that India specifically loses 6.4% of its GDP every year to water and sanitation related diseases~~ [35]. ~~.[22]

Locally, a large community survey of Kaula Bandar showed that 39.3% of individuals felt that the community's lack of water negatively affected their ability to go to work, 9.2% to go to school, 4% to study, 1.4% to start a new business, 1.5% to increase productivity in current business~~ [8]. However~~.[8] However, it is unknown if these effects are directly tied to the negative health implication of lacking water or other problems

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associated with poor access. Also, there are no data translating this into the actual monetary costs of the diarrheal illness in Kaula Bandar.

A study of 959 households in KB showed that a large proportion of Kaula Bandar occupants (45.7%) had monthly direct health expenditures (doctors, medicines, hospital fees) greater than 500 rupees, which for families living on meager income falls under the category of catastrophic expenditure~~ [~~.[8, ~~31].~~23]

Given high household expenditure on illness, preventative health interventions ~~would~~, implemented correctly, may not only be cost-effective but more affordable for many urban poor. This study investigates the cost of diarrheal illness in the community to determine the household monetary cost of having a member with diarrhea. These costs are calculated as direct and monetized indirect costs to determine the amount that diarrheal illness contributes to household expenditure and lost productivity. These costs are then projected for the community at large as figures to compare against the cost of potential interventions to improve water and sanitation infrastructure. While the presence of this infrastructure would not eliminate all cases of diarrhea or all modes of transmission, it would significantly reduce many common sources and the availability of clean water would allow for better hygiene to protect against some sources that are not eliminated.

Methods

Sampling and Data Collection

For data collection, two surveys were administered. The surveys were designed through community focus group discussions, the authors' experience with the community from previous work as well as extensive pretesting various versions of the survey and individual questions from January to May 2011. Official data collection for the study occurred in July 2011, during the monsoon season. This study was undertaken in collaboration with the local research organization, Partners for Urban Knowledge Action and Research (PUKAR).

Community based "barefoot researchers" trained in social science research at PUKAR who had previous experience administering surveys in the community verbally administered the surveys in the local language for this study. Using data-collectors from the community has many advantages and became essential to study of this type. It most importantly allowed the research team to gain social capital with the community and improve participation. It also allowed fine-tuning of survey questions given the insights that they provide about their own water, sanitation and health practices. These community based researchers assisted with pilot testing many questions to ensure that the questions captured the information they were intended to capture. Multiple rounds of training avoided initial disadvantages such as inconsistent survey administration with re-phrasing questions, not probing certain responses, recording assumptions instead of responses and leading questions. Additionally, a member of the study team accompanied each "barefoot researcher" in the field.

The study only had one exclusion and one inclusion criteria. Households with a head of household less than 18 years of age were excluded due to IRB approval for adults only and respondents that could reasonably answer questions about household finances were included. Most often the respondent was a woman. The term household in this study refers to all members living in a dwelling.

Baseline survey

The baseline survey included questions about water access, hygiene, and sanitation and average household expenditure on various goods in the Kaula Bandar community. These households did not necessarily have a diarrheal case. The entire community of Kaula Bandar was mapped and each household coded with an individual designation developing a comprehensive registry of households. A random number generator was then used to collect data on a sample of households from this registry resulting in 203 households in the baseline survey. This baseline survey was meant to simply get an understanding of general household income and expenditure as well as health practices to better formulate the longitudinal survey. Some questions were repeated after reformulation in the longitudinal survey based on the baseline survey results.

Longitudinal survey:

The longitudinal survey was designed to understand the direct and indirect costs associated with diarrheal cases in Kaula Bandar. Diarrhea was defined according to the World health Organization definition and study staff as well as survey respondents were taught this definition when collecting data. Direct costs included all health-care associated costs including ORS, medications, transport to reach a provider and provider fees as well ~~as increased~~. Avoidance costs ~~due to~~included expenses from the extra water purchased, extra kerosene purchased for boiling and extra money spent on accessing a toilet facility. Indirect costs included wages lost by earners with diarrhea or those caring for persons with diarrhea and households chores not completed.

During the month of July 2011, the community barefoot researchers visited all 2922 households in Kaula Bandar weekly for a total of five weeks. This period of five weeks was used in order to collect a reasonable sample of households representing almost 10% of the calendar year and stay within the constraints of the resources available. If a head of household over 18 years of age was available, and the household had a case of diarrhea for which the disease course had been completed during the past week, they were invited to participate in the study. Survey data were only collected for households with a completed case of diarrhea so that the data would reflect full costs for the entire episode of illness. Active, ongoing cases were recorded every week so that researchers could specifically follow-up with those households the next week (once the diarrheal illness was completed) with the full survey questionnaire. Four hundred households with a case of diarrhea contributed to the weekly survey data during the five week study period in the month of July 2011.

Given that the majority of women in this community are not wage earners, we attempted to capture the productivity that homemakers provide to the household and the amount of that productivity that is lost by diarrheal illness as an opportunity cost. Using a replacement value methodology with a hypothetical maid and focusing on 9 major daily tasks conducted by women with a an urban replacement cost of $6.1 USD or 274 rupees per task per month during the time of this study, we calculated the total indirect costs to households from a women's lost productivity.[24] The 274 rupees per month per daily task convert into an average cost of 9 rupees per individual task. To ensure that only chores that were foregone are included, women were asked to report if these chores were actually not done or they were completed with free help from another another person or simply delayed in the day or week. The opportunity cost was then the product of the forgone number chores and the cost to hire a person to complete that chore using the hypothetical maid and urban replacement cost above.

Data analysis:

The data was recorded by hand on paper and transferred to an EpiData database by the data manager as soon as results were provided to PUKAR. Statistical analysis was performed using STATA MP ver. 10, College Station, TX. Data on cost measures from the longitudinal survey were analyzed after eliminating the top 5% and bottom 5% of values among the population to exclude the effect of outliers. Although some catastrophic events may have been excluded by this process, we found that the mean and median values did not differ greatly but some variability at the two ends was eliminated by eliminating the outliers.

Data storage

Only researchers associated with the PUKAR team had access to the survey information. All data regarding specific homes from which data was collected was stored at the PUKAR office on a password protected hard disk. All results of the study were analyzed and are published in an anonymized fashion.

Ethical Considerations

Heads of households provided informed consent. The households who participated in the study as well as other residents received education on recognizing signs and symptoms of diarrhea through pictorial posters. The female members of the household who usually bore the brunt of caretaking for persons with diarrhea in the home were taught about initial treatments such as ORS and were educated on when their family members should been seen by a doctor in case of deterioration in condition. This study received Institutional Review Board (IRB) approval from PUKAR Institutional Ethics Committee as well as the Partners Human Research Committee associated with Harvard Medical School based researchers in Boston, MA USA.

Results:

A total of 203 households, 6.9% of the 2922 households in the community, provided data for the baseline survey. Systematically visiting every household for the weekly longitudinal survey resulted in 400 households providing data as these were the homes with completed diarrhea cases during the study period. ~~The sample of 400 households represents 13.7% of Kaula Bandar homes.~~ There was some repetition with 49 homes reporting cases twice within the study period and 9 households reporting three weeks with a case of diarrhea. The sample of 400 household events represents 13.7% of Kaula Bandar homes. The age distribution of cases showed that all children under five years of age accounted for 35% of cases while those under one-year accounted for 11%. Those aged 5-18 years accounted for another 25% of cases and adults made up the reaming 40%.

The percentage of homes occupied and thus available for survey every given week ranged from 67% to 73.2%, showing that at least 2/3 of the community was available for survey each week. Of these available households, there was a negligible non-response rate ranging from 0.5% to 1.2%, thus, having minimal effect on the study results.

Baseline demographic information from the baseline survey, displayed in Table 1, shows that the population of this slum is predominantly male and young with 1.2 males for every female ~~with a median age of 20.~~. Part of this ratio is related to the presence of many single migrant laborers in the community. Additionally, only about 10% of the population was over the age of 40. Children under five years of age, representing the most vulnerable population to diarrheal illness, make up slightly over 15% of the population.

General household financial data from the baseline survey, displayed in Table ~~2~~1, shows basic income and consumption information. ~~While household income ranged in a normal distribution, the median income in this community from both the baseline and weekly surveys falls between 5000 to 6000 rupees per month.~~ Each household had on average 1.7 wage earners per household with 32% of the population earning a wage. ~~About 26.6%~~Of the roughly quarter of ~~the~~ households that are able to save ~~some money~~ each month ~~and of those that save~~, the median savings in 1500 rupees.

After discussions with households and advice from persons within the community, household costs were broken down into several major categories: rent, food, water, electricity and kerosene. While these categories do not comprehensively capture the total costs of each household, they represent the major recurring basic costs that each household incurs for their general welfare. The average monthly expenditure on these basics excluding water was 4,609 rupees with an additional median of 300-450 rupees spent on water alone.

Diarrhea in this community was reported on a weekly basis during the 5-week course of the study as active cases and cases that had just completed that week. The general weekly prevalence of diarrhea per household ranged from 5.9% to 9.2% during this monsoon season. ~~This is likely a higher prevalence for this community as compared to the general year given the season, which induces more flooding and, thus, greater contact with fecal coliforms as well as increased water source contamination.~~

The costs of diarrhea to these households was measured and reported here in terms of direct ~~and indirect~~medical costs, ~~Tables 3.~~ avoidance costs and lost wages from income and costs from homemakers' productivity loss, Table 2.

Basic direct costs included all health-care associated costs including ORS, medications, transport to a provider and provider fees. ~~Other direct~~Although transport to a provider is commonly considered a non-medical cost, we combine it here because access to healthcare is a major issue for the urban poor and transport to a healthcare provider is an important part of the cost to access healthcare. The majority of people, 62%, accessed a private provider with a local doctor and 15% went to a pharmacy for care.

Avoidance costs were tabulated separately as increased costs due to the extra water purchased, extra kerosene purchased for boiling and extra money spent on accessing a toilet facility. ~~Indirect costs represented the wages lost by earners with diarrhea or those caring for persons with diarrhea and household chores not completed. While some of the indirect costs have a specific monetary value, lost time and household chores are extrapolated.~~

~~The mean basic direct cost for each household~~

Lost wages represented the wages lost by income-earners with diarrhea ~~was 205 rupees. The total other direct costs (water, kerosene, toilet) resulted in a mean of 86 rupees per household.~~or those caring for persons with diarrhea. In the community, 16.5% of households lost some wages from income-earning employment due to diarrhea ~~and while~~. While this value varied, these households lost a median of 500 rupees of income for the episode from missed employment. Spreading this loss over all the households and calculating the loss overall yields a mean loss of 55 rupees per household.

~~Given that the majority of women in this community are not wage earners, we attempted to capture the productivity that homemakers provide to the household and the amount of that productivity that is lost by diarrheal illness. Using a replacement value methodology with a hypothetical maid and focusing on 9 major daily tasks conducted by women with a an urban replacement cost of $6.1 USD or 274 rupees per task per month during the time of this study, we calculated the total indirect costs to households from a women's lost productivity [37]. The 274 rupees per month per daily task converts into an average cost of 9 rupees per individual task. On average, women in the household with~~

On average, women in the household with a case of diarrhea were unable to complete an average of 7 tasks that week due to a case of diarrhea in the household ~~translating into a loss of 63 rupees per household.~~. The cost from the monetized value of foregone chores based on the replacement cost method of hiring a maid is reported.

Given the values above, the cost of illness to each household from a case of diarrhea can be reported in several ways. The basic direct cost is 205 rupees. ~~Other direct~~Avoidance costs of 86 rupees gives a total of 291 rupees. Adding the mean loss of 55 rupees per household from lost ~~wages~~income brings the total to 346 rupees per household and adding the monetized ~~lost~~ productivity lost from homemakers of 63 rupees brings the total to 409 rupees.

Simply using the 400 cases of diarrhea from this community found during this 5-week study period from the houses available for survey alone yields a total basic direct cost of 82,000 rupees or $1,822 USD using the exchange rate present at time of study. The complete total cost of 409 rupees per household yields a loss of 163,600 rupees or $3,635 USD to the community over the five-week study period.

These results rely on household incidence of diarrhea regardless of age and no reliable measure of diarrheal incidence at the household unit exists for a similar population to estimate the yearly costs for this population. Using a conservative assumption, however, that each household will suffer at least one case of diarrhea per year, the basic direct cost of diarrheal illness in this community of 2922 households yields a yearly total community-wide cost of 1,195,098 rupees ($26,557 USD).

Table 1: ~~Baseline Demographic~~General Household Information from Baseline Survey

Male	55%
Female	45%
Age (median)	20 years
Children under 5	15%

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~~Table 2: General Household Financial Information (All amounts reported in rupees [Rs])~~

Income (median)	Rs 5000-5999
Basic monthly expenses (Rent,	Rs 4609

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food, electricity, kerosene)	
Water expenses (median)	Rs 300-449
Possess ration card	68.5%
Save money each month	26.6%

Table ~~3~~2: Mean Household Costs per Diarrheal Illness in Rupees (Rs) ± Standard Deviation (SD)

Metric	Cost ± SD	n
Basic direct costs *(ORS, provider fee, transport, medication costs)*	205 ± 190	310
~~Other direct~~Avoidance costs (*extra water, kerosene and toilet fees)*	86 ± 81	201
Lost wages from income	55 ± 160	384
Homemaker's productivity loss ~~–~~ *(foregone chores monetized)*	63	400
Total	409	

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Discussion:

This study provides direct household level data on the cost of diarrheal illness to urban slum residents in this community. Longitudinally interviewing every available household consecutively for five straight weeks provides rigorous insight into the weekly income and expenditure habits of these residents as they relate to diarrheal illness. Given the thorough nature of the data collection, this study provides strong evidence that diarrheal illness incurs significant ~~direct and indirect~~ costs to urban slum households. More importantly, this study ~~shows how over a very short period of time,~~provides expenditure and illness costs that can be compared against the cost of infrastructure upgrades for water and sanitation systems ~~that transfer~~. The savings from lower costs of water and sanitation from improved infrastructure can be put towards paying for that infrastructure and over time completely finance it. This study provides evidence that the savings from a reduction in some cases of diarrhea from such infrastructure may also help finance it by these costs from the back end of paying for illness to the front end could pay for themselves. With every illness episode ~~costing~~ each household loses an average of ~~248~~205 rupees in direct basic costs and ~~515~~346 rupees in total avoidable total costs. Reducing ~~and eliminating~~ these illness episodes can provide a significant savings benefit that can be used to finance the infrastructure upgrades.

This study adds further evidence ~~against~~to break the myth that urban slum populations do not have the financial capacity to pay for improved infrastructure. Just as many reports have shown that these households in fact pay a high price for basic goods and services from both official and unofficial sources, this study shows that households also pay a high price for illness~~.~~ given that it represents 7-8 percent of their monthly income and almost 30% of their weekly income. While not a novel concept, this study provides concrete numbers on the cost that illness inflicts on the urban poor and shows how these households, as a community, have the financial capacity to finance infrastructure they need simply from the savings in prevented illness. Although this is not an argument for such a model, it adds further evidence that upfront investment in basic infrastructure ~~is cost-effective.~~can be financially supported by a resulting reduction in

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illness. The savings realized by these households from an infrastructure investment could then be put towards other basic needs in nutrition, education and health.

Despite the rigorous methodology, the study suffers from a few limitations. While the values for cost are rigorously collected from every available household, they are the best estimate from the surveyed adult. The data were not gathered from detailed budgets, financial diaries or accounts held by these households but rather by recall. The diversity of the population within this community added to the variability and high standard deviations seen in the data. This reflects the true nature of many urban slums that have a high variability in socio-economic status. Another limitation is that while improved water and sanitation infrastructure can have a significant impact on reducing illness, proper hygiene plays another major role. Infrastructure upgrades alone will not eliminate the burden of diarrheal illness and thus, all of the cost from diarrheal illness cannot be attributed to the lack of such infrastructure. Accordingly, the total savings realized by such an infrastructure upgrade would be less. This community, however, has a high reported rate of hand hygiene with 86% of households washing their hands before eating and 90% washing their hands after defecating. Additionally, 87% of the population reported using soap either before eating, after defecating or both. Thus, most of the costs estimated from this study are all likely costs that can be saved through infrastructure upgrades to compliment this hand hygiene. While estimates on the exact magnitude of benefit from water and sanitation infrastructure vary, a recent ~~review~~meta-analysis of interventions in developing countries concluded that ~~piped~~improved water ~~to each household alone~~supply could ~~give up to 63% reduction in diarrheal prevalence [38]. Adding a~~reduce diarrhea by about 25%.[25] A sanitation intervention would further ~~reduce this prevalence~~provide reductions. This meta-analysis concluded that a combination of multiple interventions including improved water supply and ~~allow more complete cost recovery. Unlike~~ quality, improved sanitation and hygiene could reduce diarrheal disease by 33%.[25] Given that hand hygiene ~~compliance, only~~was high in this community, the estimated reduction in diarrhea by a combined water and sanitation intervention would likely be slightly less.

Only 56.5% persons with diarrhea in this study used ORS~~ and a~~. A higher rate of early ORS use might have averted more costly healthcare expenses ~~contributing to~~such as the need to access a healthcare provider thereby reducing the overall cost ~~estimates~~of the illness measured in this study. This limitation is hypothetical, however, ~~in that~~because it is unclear if any of the cases that did not use ORS would have needed it or ~~even sought~~if they were associated with seeking more expensive care elsewhere to increase the household costs. Finally, the care-seeking behavior for diarrhea itself may be viewed as a limitation as most cases do not require care outside the home and better education might prevent these costs from being incurred by families. Whatever the impact of improved care-seeking behavior on the cost estimates, however, this study estimates the current real cost households incur due to diarrheal illness which can be saved and put towards public health interventions aimed at reducing this burden, including infrastructure upgrades.

Many of the estimates of cost here may actually be underestimates. ~~As this~~ This particular community did not have many female ~~wage~~income earners in the household~~, another community with more female wage earners (common among~~. Many urban ~~households) would presumably~~slum communities have ~~had~~ a higher ~~indirect cost~~rate of ~~lost wages~~women that are employed in the informal sector but still live in communities such as this one with poor water and sanitation infrastructure. If that informal employment were outside the home, they would forgo income from having to stay home with an ill child. Additionally, the time spent on activities such as travelling to the toilet and fetching water were not adequately collected in this study, adding further indirect costs to diarrheal illness not included in this estimate. We could not collect enough data on savings and debt among these households to make a correlation between illness and debt in this community but previous studies have shown that illness is an indebting event for many urban poor. A larger and more comprehensive study may have been able to capture that value showing a further cost in the lost savings and higher payments made on loans for such borrowing. ~~Finally, the weight of evidence that diarrheal illness incurs even greater indirect costs than those measured here is staggering [38]. When~~Finally, if malnutrition, stunting, poor school performance, delayed and incomplete education and poor cognitive development ~~are~~could be included along with the resulting decreased economic opportunities as well as mortality on overall GDP, there ~~is~~would be an even greater cost attributable to diarrheal illness in urban slum communities similar to Kaula Bandar.

Given the study findings, policy-makers and those with programs aimed at aiding urban slum populations should understand the potential savings from preventing diarrheal illness with improved water and sanitation infrastructure. A current intervention to provide piped water to Kaula Bandar has an estimated cost of 2.5 million rupees. While this intervention will not provide each household with ~~an individual~~a personal tap, community taps that increase water availability and ensure quality have the potential to reduce diarrhea ~~by 25%~~morbidity. The potential reduction in diarrhea from such an intervention~~. Using even this modest estimate of reduction, one can easily see how~~ may aid the community ~~can~~to help finance this intervention over a ~~relatively short~~ period of time from the lower diarrheal cost savings ~~alone.~~ by adding to the savings from cheaper water.

This financial argument for water and sanitation infrastructure complements the right to water and sanitation that all persons have. This right to water and sanitation is part of a larger legal and human rights framework. On July 28th, 2010 the UN General Assembly adopted resolution 64/292 acknowledging that clean water and sanitation are essential to achieving all human rights~~ [41].~~.[26] International organizations and all states and are directed to provide adequate and affordable access to clean water and sanitation for all persons. This research on the community and household financial implications of poor water and sanitation adds to this human rights approach with a further pragmatic and operational validation of the need for clean water and sanitation provision to even the most difficult to reach populations.

This study ~~shows that programs~~provides data on the cost of diarrheal illness to urban slum households and ~~policies that allow communities to~~ allows an analysis of cost-recovery for various interventions. This study begins to explore how the expected health benefits may help finance ~~and fund~~ such interventions ~~are possible~~in urban slum communities. Whether government financed through taxes or privately through fees or micro lending or even socially through savings cooperatives, financial vehicles to promote infrastructures upgrades ~~can~~may be financially viable methods of development. While this study argues for improved infrastructure, the potential cost savings from improved health and illness prevention ~~can~~may be used to finance various types of health promotion and public health activities. These potential savings should be calculated and considered in cost-benefit analyses. Further research is needed on the best methods of preventing illness, improving care-seeking behavior and healthcare quality among urban slum communities. ~~This study shows that such interventions in urban slum communities can be financed through improving the consequent health benefits.~~

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.